WORK STATUS REPORT

JS-508

Period: June 1 through June 30, 1967

MICRODENSITOMETER SUPPORT

by

July 7, 1967

INTRODUCTION

This progress report covers the period from 1 June through 30 June 1967. The financial information included in this report is for the entire contract period from 2 November 1966 through 31 May 1967.

PROGRESS DURING THE PERIOD

Color Image Assessment - Analytical Aspects

The approach to the research investigation of color image assessment has now been sufficiently well defined to permit a flow chart to be prepared that outlines the different sub-tasks contributing to the accomplishment of the final goal. This flow chart is shown in the figure. At the present time there are no identifiable problem areas that will prevent completing these tasks within the present contract period and funds.

During this report period computation techniques have been developed that incorporate the degree of sophistication required to handle the color image assessment problem. These techniques will now be described in some detail.

A radiant analytical weighted (RAW) exposure computer program has been developed to predict the maximum exposure given to each layer of the color film. This computation takes into consideration the spectral qualities of the light source, the filtration and the spectral signature of the reflecting object. With this program our sensitometer has been recalibrated to provide RAW exposures for Ektachrome daylight type original material and Ektachrome camouflage detection film.

A direction cosine computer program was completed and tested during the report period. This program checks the spectral orthogonality of the individual microdensitometer channels and may also be utilized in testing the orthogonality of individual dyes in a given color film. Knowledge of the dynamic range over which the direction cosine between two dyes is constant permits an analytical expression to be written over that range.

A new type of combined ensemble averaging and granularity program has also been developed. Among the features of this computer program are user-specified sample length and automatic output of the mean and standard deviation when a change is detected in the mean of the population being scanned. This program is designed for use with either long, continuous records or raster scans without operator intervention.

During the report period work was begun on writing a subroutine for the determination of cyan, magenta and yellow analytical filter densities. This is a straightforward matrix multiplication routine that takes trichromatic densities from a given set of coordinates and maps them into analytical densities through the relationship

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = A^{-1} \cdot \begin{bmatrix} D_r \\ D_g \\ D_b \end{bmatrix}$$

where A^{-1} is the inverse of the dye system calibration matrix. The direction cosine dye analysis will indicate the dynamic range over which the matrix is valid. The numerical evaluation of the A mapping matrix has been initiated with the separation of dyes from the color tripack by selective exposure.

A computer program for converting the tape data from the Data Logger to IBM/360 code has been completed. A detailed description of this program is included in the Appendix.

The theoretical work required to implement the color effective exposure concept has been completed, and a start has been made in the programming and development of calibration techniques for the effective exposure system. This system, where operative, will automatically correct the exposure tables for each emulsion of the integral tripack, depending on the color of the object being scanned. This procedure is necessary since research to date indicates that the characteristic curves of color transparency materials change as a function of the spectral properties of the exposing source. The possibility exists that additional work on the concept evolved for handling effective exposure conversion may also provide a means for treating the spectral signature problem.

<u>Color Image Assessment - Experimental Aspects</u>

The effort to generate complete sets of red, blue and green sine waves continued during the report period and the set of green sine waves was completed.

The mercury-cadmium source was received but did not prove suitable for generating red sine waves because of its low intensity. This problem was not completely unexpected. Preliminary test exposures using a He-Ne laser (6328 A) indicate that the anticipated disadvantages of this highly coherent source can be overcome so that it can be used to generate the red sine waves.

Neutral edges were exposed on SO-151 film and developed in the color Versamat. Edges of various contrast were used, and an exposure series was made for each contrast.

A xenon flash served as the light source for the edge exposures so that a good color balance, approximating that of daylight, was expected. The edges turned out to be somewhat green in color but are still useful for an initial attempt at color edge analysis.

Part of the difficulty in obtaining accurate color correction may be the result of reciprocity failure; in color photography reciprocity failure is more serious than in black and white since corrective action during exposure and processing cannot be taken. It is expected, however, that this problem will be overcome.

Grainless wedges were exposed on SO-151 film using a special frame constructed for this purpose. In this context grainless wedges are defined to have no superimposed granularity or, more simply, to have only the inherent granularity of the film on each step of the wedge.

These wedges will be used to obtain an estimate of the granular noise at each exposure level. A measure of the independence of the granular noise will be obtained by computing the cross correlation function associated with each of the three color traces and comparing it with the autocorrelation functions of the individual traces.

Reciprocity failure again contributed to a color balance error, especially in the higher density steps. The wedges are still usable nevertheless.

WORK PLANNED FOR NEXT PERIOD

1. The computer programming effort will continue with the possibility that the effective exposure generator for color materials will be completed.

2. Completion of the data set for the red sine waves.

3. Grainless step wedges, and instructions for tracing them on the trichromatic microdensitometer, will be delivered to the customer. If results are unsatisfactory, the color balance problem will be corrected.

4. If wedge traces are received from the customer, initial testing of the effective exposure generator program will begin.

5. Sine waves will be exposed on film in which two color sensitive layers have been fogged out.

6. Complex edge and comb targetry generation will be initiated upon receipt of the target mirror that has been ordered.

STATINTL

FINANCIAL INFORMATION

Total amount authorized . . . .

Total amount expended through May 31, 1967 . . . .

Total amount remaining as of May 31, 1967 . . . .

Total man-hours expended through May 31, 1967 . . . .

APPENDIX

STATINTL

CONVERSION OF [redacted] DATA TO IBM/360 DATA

STATINTL

STATINTL

There are going to be four kinds of information on the tape coming from the [redacted] digitizer. They will occur in two kinds of blocks, ID blocks and data blocks. An ID block is <u>defined</u> as a block which is 72 characters long and which begins with the [redacted] characters ++ or +b̸ (b̸ = blank). [redacted] characters are defined in the write-up on the digitizers. As far as the IBM/360 is concerned, the + character is the hexadecimal character x'10', and blank is x'30', before they are translated to the IBM/360 character set. Any block which does not begin ++ or +b̸ is <u>defined</u> to be a data block, regardless of its length.

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An ID block is translated from [redacted] code to IBM/360 code (EBCDIC), printed on the printer, and moved to the first 72 bytes of the next disk output record. If ID blocks occur amidst the data, the current output data block will be filled out with the value -1. An ID block can be recognized by the FORTRAN program when reading from the disk because the first word of the block will have an integral value greater than 10^9. The FORTRAN programmer can have access to this block either by reading it again under FORMAT control or by displaying it on the printer or console. Since it is not conveniently possible to read data beginning in the middle of a block, each ID block read will be written on disk as a separate disk record. In order to assure enough space to write each ID block, a minimum disk file block length of 18 words, or 72 bytes, is required. The maximum block length is limited by FORTRAN to 1,600 bytes or 400 words. Any convenient block size in this range may be selected, but it is well to remember that if many ID blocks are expected, shorter blocks will waste less space. If ID blocks will be infrequent, longer blocks waste less space because of the smaller number of space-consuming interblock gaps. In any case the block length should be a multiple of three words (12 bytes) for reasons which will be apparent from what follows.

STATINTL

A normal data block on the [redacted] tape is 720 characters long in the form of 90 eight-character words. Truncated blocks may be shorter but will always have an integral number of eight-character words in them. The accumulation of data will begin immediately following the reading of the last ID block, and the data will be copied to the disk beginning at the nineteenth word of the block currently in use. There are three recognizable types of data, and each will be written on the disk in a similar fashion. All data will be written in three-word groups. Normal density information will be written STATINTL as integral "[redacted] Density Units"*, one density value to a word, three words to a group. If data is not taken for the second or third word of a group, the value -1 will be inserted in the space remaining so that an integral multiple of three words will be written. Incomplete blocks will likewise be filled with -1's, as explained above, when ID blocks are encountered. As data is being recorded, it will frequently happen that a coordinate block will be encountered. Generally speaking, there will be two such blocks per scan. At the beginning of a scan the x and y coordinates of the point where the first density value recorded was measured are written on the tape. At the end of a scan the x and y coordinates are again recorded, but they do not necessarily correspond to the location of any point where density was measured. For convenience in differentiating between coordinate values and density values, the first word of a group of three words containing coordinate data will have the magnitude 1,000,000. The beginning-of-scan coordinates will be preceded by +1,000,000, and the scan-interrupted coordinates will be preceded by -1,000,000. The second word of a coordinate group will contain the value of X (as an integer) and the third word will contain the value of Y. Density data will be placed in succeeding groups of three words in the output block until the block is full or the data are exhausted, just as though no coordinate information had been encountered.

The possibility exists of more than one file of data being written on a single tape. For this reason, each time a tape mark is encountered, the operator is given the opportunity of terminating the run. In addition, if two consecutive tape marks are read, or if an ID block of the form "++ƀƀENDƀOFƀTAPE" is encountered, the run will be terminated. Individual files may be selected from a multi-file tape by use of the control

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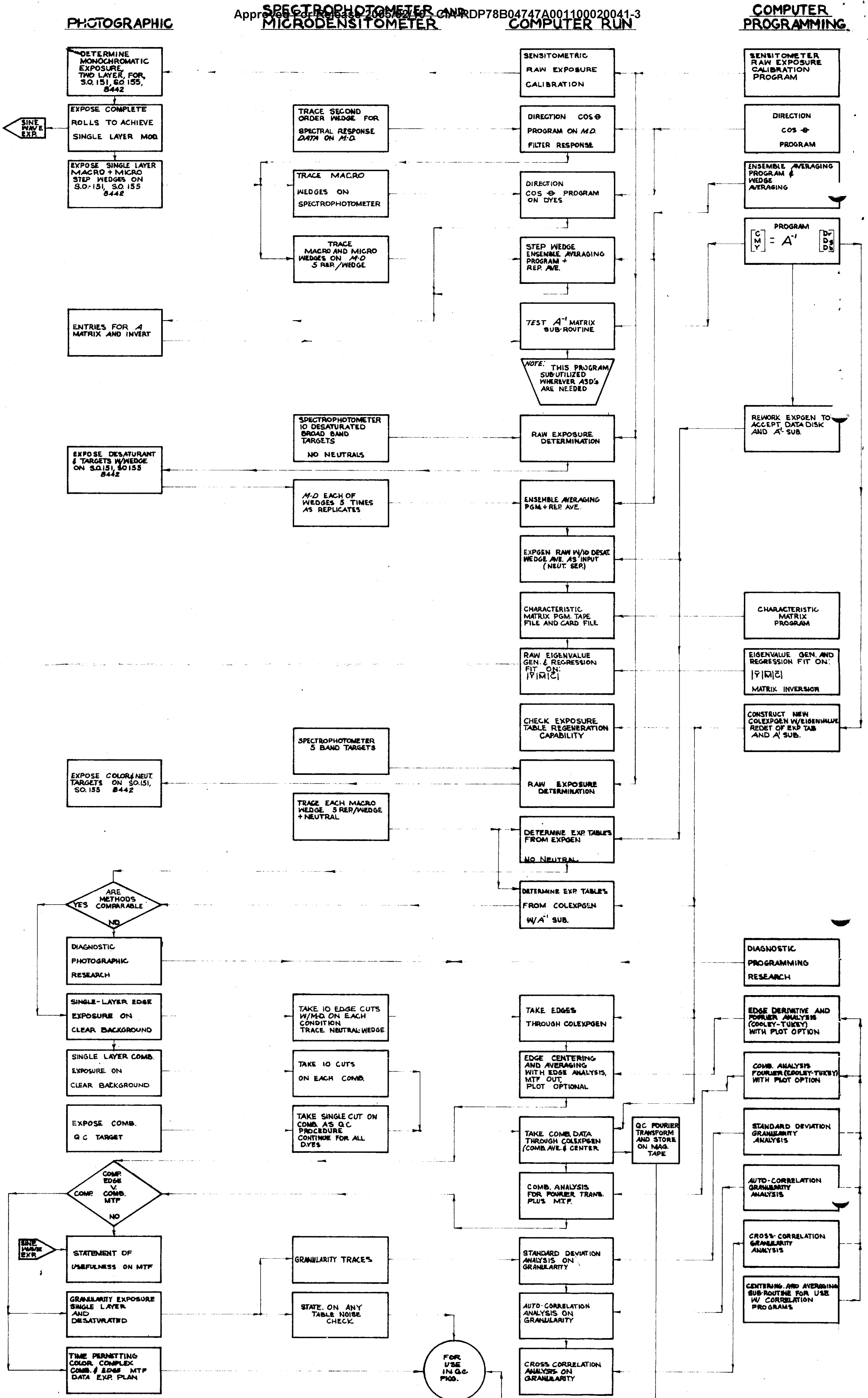
* A "[redacted] Density Unit" is the value of one bit in the 10-bit binary value written by the [redacted] Data Logger. Its value in terms of standard photographic density is not well defined.

card* "//␢MTC␢FSF,SYS004,nn", where "nn" is the number of tape marks it is desired to by-pass before beginning to read the tape. By writing tape marks down the length of a tape before recording on it, or by writing several tape marks ad lib after the run, it can be assured that the program will not translate any invalid data.

* Information about this and other control cards can be obtained from the manual "IBM System/360 Disk Operating System: System Control and System Service Programs".


PHOTOGRAPHIC
SPECTROPHOTOMETER AND MICRODENSITOMETER
COMPUTER RUN
COMPUTER PROGRAMMING
DETERMINE MONOCHROMATIC EXPOSURE, TWO LAYER, FOR, S.O. 151, SO 155, 8442
EXPOSE COMPLETE ROLLS TO ACHIEVE SINGLE LAYER MOD.
SINE WAVE EXP.
EXPOSE SINGLE LAYER MACRO + MICRO STEP WEDGES ON S.O.-151, S.O. 155 8442
ENTRIES FOR A MATRIX AND INVERT
EXPOSE DESATURANT & TARGETS W/WEDGE ON S.O.151, S.O.155 8442
EXPOSE COLOR & NEUT. TARGETS ON S.O.151, S.O. 155 8442
ARE METHODS COMPARABLE
YES
NO
DIAGNOSTIC PHOTOGRAPHIC RESEARCH
SINGLE-LAYER EDGE EXPOSURE ON CLEAR BACKGROUND
SINGLE LAYER COMB. EXPOSURE ON CLEAR BACKGROUND
EXPOSE COMB. Q C TARGET
COMP. EDGE V. COMB. MTF
COMP.
NO
SINE WAVE EXP.
STATEMENT OF USEFULNESS ON MTF
GRANULARITY EXPOSURE SINGLE LAYER AND DESATURATED
TIME PERMITTING COLOR COMPLEX COMB. & EDGE MTF DATA EXP. PLAN
TRACE SECOND ORDER WEDGE FOR SPECTRAL RESPONSE DATA ON M.D.
TRACE MACRO WEDGES ON SPECTROPHOTOMETER
TRACE MACRO AND MICRO WEDGES ON M.D 5 REP./WEDGE
SPECTROPHOTOMETER 10 DESATURATED BROAD BAND TARGETS NO NEUTRALS
M.D EACH OF WEDGES 5 TIMES AS REPLICATES
SPECTROPHOTOMETER 5 BAND TARGETS
TRACE EACH MACRO WEDGE 5 REP./WEDGE + NEUTRAL
TAKE 10 EDGE CUTS W/M.D. ON EACH CONDITION TRACE NEUTRAL WEDGE
TAKE 10 CUTS ON EACH COMB.
TAKE SINGLE CUT ON COMB. AS Q.C PROCEDURE CONTINUE FOR ALL DYES
GRANULARITY TRACES
STATE. ON ANY TABLE NOISE CHECK
FOR USE IN Q.C. PKG.
SENSITOMETRIC RAW EXPOSURE CALIBRATION
DIRECTION COS θ PROGRAM ON M.D. FILTER RESPONSE
DIRECTION COS θ PROGRAM ON DYES
STEP WEDGE ENSEMBLE AVERAGING PROGRAM + REP. AVE.
TEST A⁻¹ MATRIX SUB-ROUTINE
NOTE: THIS PROGRAM SUB-UTILIZED WHEREVER ASD's ARE NEEDED
RAW EXPOSURE DETERMINATION
ENSEMBLE AVERAGING PGM.+ REP. AVE.
EXPGEN RAW W/10 DESAT. WEDGE AVE. AS INPUT (NEUT. SEP.)
CHARACTERISTIC MATRIX PGM. TAPE FILE AND CARD FILE
RAW EIGENVALUE GEN. & REGRESSION FIT ON: |Ȳ|M|C̄|
CHECK EXPOSURE TABLE REGENERATION CAPABILITY
RAW EXPOSURE DETERMINATION
DETERMINE EXP. TABLES FROM EXPGEN NO NEUTRAL
DETERMINE EXP. TABLES FROM COLEXPGEN W/A⁻¹ SUB.
TAKE EDGES THROUGH COLEXPGEN
EDGE CENTERING AND AVERAGING WITH EDGE ANALYSIS, MTF OUT, PLOT OPTIONAL
TAKE COMB. DATA THROUGH COLEXPGEN (COMB. AVE. & CENTER
Q.C FOURIER TRANSFORM AND STORE ON MAG. TAPE
COMB. ANALYSIS FOR FOURIER TRANS. PLUS M.T.F.
STANDARD DEVIATION ANALYSIS ON GRANULARITY
AUTO-CORRELATION ANALYSIS ON GRANULARITY
CROSS CORRELATION ANALYSIS ON GRANULARITY
SENSITOMETER RAW EXPOSURE CALIBRATION PROGRAM
DIRECTION COS θ PROGRAM
ENSEMBLE AVERAGING PROGRAM & WEDGE AVERAGING
PROGRAM
[C M Y] = A⁻¹ [D_r D_g D_b]
REWORK EXPGEN TO ACCEPT DATA DISK AND A⁻¹ SUB.
CHARACTERISTIC MATRIX PROGRAM
EIGENVALUE GEN. AND REGRESSION FIT ON: |Ȳ|M|C̄| MATRIX INVERSION
CONSTRUCT NEW COLEXPGEN W/EIGENVALUE REDEF. OF EXP TAB AND A⁻¹ SUB.
DIAGNOSTIC PROGRAMMING RESEARCH
EDGE DERIVATIVE AND FOURIER ANALYSIS (COOLEY-TUKEY) WITH PLOT OPTION
COMB. ANALYSIS FOURIER (COOLEY-TUKEY) WITH PLOT OPTION
STANDARD DEVIATION GRANULARITY ANALYSIS
AUTO-CORRELATION GRANULARITY ANALYSIS
CROSS-CORRELATION GRANULARITY ANALYSIS
CENTERING AND AVERAGING SUB-ROUTINE FOR USE W/ CORRELATION PROGRAMS